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ABSTRACT

Samples of 17 male and 31 female first graders, 26 male and 22 female third graders, 23 male and 25 female fifth graders, 21 male and 27 female ninth graders, and 18 male and 30 female college students predicted their ability to recall sets of items that varied in number of items presented and presence or absence of categorization. The aim was to assess the developmental emergence of children's understanding of number, memory span, categorization, and interaction of number and categorization. Principal findings were: (1) first graders grossly overestimated their recall abilities; (2) third and fifth graders overestimated recall ability for uncategorized lists, but not for categorized items; (3) adults slightly underestimated their ability to recall both categorized and uncategorized lists; and (4) adults and adolescents recognized that categorization of items benefited recall only when list length exceeded immediate memory span. Developmental differences were also found in the type of information or evaluative rules children and adults use as the basis for their predictions. Young children's predictions conformed to rules that reflected consideration of only one variable (e.g., number of items presented), whereas predictions of adolescents and adults were based on understanding of list length, categorization of items, and the relationship of these two variables to immediate memory span. (RH)

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Children's Understanding of Factors Influencing Recall Performance

Catherine A. Hale

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Poster presented at SRCD, 1987. For a complete description of the study please write: Catherine Hale, Department of Psychology, Saint Mary's College, Notre Dame, IN 46556

ABSTRACT

First, third, fifth, and ninth graders and college students predicted their ability to recall sets of items that varied in the number of items presented and presence or absence of categorization. The aim was to assess the developmental emergence of children's understanding of number, memory span, categorization, and the interaction of number and categorization. The principal findings were: (1) first graders grossly overestimated their recall abilities; (2) third and fifth graders overestimated recall ability for uncategorized lists, but not for categorized items; (3) adults slightly underestimated their ability to recall both categorized and uncategorized lists; and (4) adults and adolescents recognized that categorization of items benefited recall only when list length exceeded immediate memory span. Developmental differences were also found in the type of information or evaluative rules children and adults use as the basis for their predictions. Young children's predictions conformed to rules that reflected consideration of only one variable (e.g., number of items presented) whereas predictions of adolescents and adults were based on understanding of list length, categorization of items, and the relationship of these two variables to immediate memory span.

AIMS

In the present study, first-, third-, fifth-, and ninth-graders' and college students' understanding of number, categorization, memory span, and the interaction of these variables was assessed using a task that required subjects' predictions of recall ability with sets of items that differed in the number of items presented and categorization of items. To assess what information children and adults used as the basis for their predictions, seven plausible rules were proposed (Table 1). The rules allowed assessment of whether subjects based their predictions solely on the number of items presented (Rules A and B), solely on categorization (Rule C), or considered both number of items and categorization (Rules D, E, F, & G). The rules further distinguished between subjects whose predictions reflected understanding of immediate memory span (users of Rules B, F, & G) as well as those that did not (users of Rules A, C, D, & E). Thus the present study was designed to address two questions: (1) are there developmental differences in children's predictions of their own recall; and (2) what evaluative rules do children use to form their predictions.

METHOD

Subjects

Participants were 17 boys and 31 girls in Grade 1 (mean age = 6.52, range 6 to 8 years), 26 boys and 22 girls in Grade 3 (mean age = 8.88, range 8 to 10 years), 23 boys and 25 girls in Grade 5 (mean age = 10.67, range 10 to 12 years), 21 boys and 27 girls in Grade 9 (mean age = 14.48, range 12-16), and 18 male and 30 female college students (mean age = 21.23, range 18 to 39 years).

Materials

The stimuli used for the prediction task were pictures of common items such as instances of food, furniture, or toys mounted on pieces of black cardboard. There were 24 cards, reflecting two instances in each cell of the factorial combination of number of items depicted per card (4, 6, 8, 10, 12, or 20) and the presence or absence of categorization.

Procedure

Subjects were given memory and prediction pretraining and then the prediction task. To ensure that any developmental differences in rule usage and prediction was due to understanding of the memory variables and not to the differential impact of number and categorization on recall

performance, one-third of the subjects were additionally given a recall task.

Memory Pretraining. A recall task was given in which three cards--depicting a car, hamburger, and a flower--were placed in a row in front of the participant, who was asked to remember the objects. After five seconds, the cards were removed and the participant was asked to recall the items. All subjects were able to recall the items correctly on the first trial.

Prediction Pretraining. Subjects were shown a prediction card with 21 columns and were told "See this card. Each of these has a different number of squares in it. Show me the one that has four squares, ten squares, seventeen squares." The experimenter continued to probe the participant until she was certain the subject understood that each column represented a specific number.

Prediction Task. Each of the 24 problems was presented individually in random order. Before each problem was presented, the appropriate prediction card was placed in front of the subject. The participant was then told, "If I asked you to remember all of these pictures, show me on this card how many you think you could remember." Children were allowed 15 seconds to indicate their response on the card.

Recall Task. In this task, participants were shown 12 cards of items that varied in number and categorization of items. Each card was presented for 25 seconds. Then the subject was given 20 seconds to recall as many of the items as he or she could remember.

RESULTS

Predictions

In the prediction task, subjects were asked to predict their ability to recall sets of items that differed in number (4, 6, 8, 10, 12, or 20 items) and conceptual relatedness (categorized or uncategorized). The prediction data were analyzed with a 5 (Age) X 2 (Category) X 6 (Number of item presented) analysis of variance with repeated measures on the last two factors.

Recall predictions as a function of category and number are presented in Table 2. Although the main effect for age was not significant, $F(4,225) < 1$, the main effects of category and number were both significant, $F(1,225) = 135.6$, $F(5,1125) = 375.9$, respectively. All two-way interactions involving age, category, and number were significant, $F's \geq 1.96$, as was the three-way interaction, $F(20,1125) = 2.99$.

Analysis of the simple two-way interaction of category and number at each age revealed that only the three oldest age groups considered the interactive nature of category and number of items when making their predictions. That is, younger children predicted that recall would increase as a function of list length, comparably for categorized and uncategorized lists. In contrast, older children's and adults' predictions reflected their

awareness that categorization benefits recall for list lengths that exceed immediate memory span (F's $\geq$ 3.24).

Use of Rules

Predictions of recall accuracy were examined for correspondence to the proposed rules. The correspondence between each subject's predictions and those derived from each rule was determined with STEPIT. This FORTRAN subroutine yields parameters that minimize the sum of the squared deviations between the subject's actual data and those generated by the equation. Determining which of the seven proposed rules best described each subject's predictions involved several steps. First, coefficients of determination (r^2) were computed to determine how much variance could be explained by each of the seven models. Rules that did not account for statistically significant amounts of variance were eliminated.

Second, a rule was eliminated if the estimated parameters were implausible. Third, shrunken r^2's, which adjust for the number of free parameters in the equations, were computed for the remaining rules. Last, the rule (or rules) with the highest descriptive power was chosen based on two separate sets of criteria. The first set of criteria consisted of selecting the rule that yielded the highest shrunken r^2 value. The second, more

stringent, set of criteria consisted of selecting the rule (or rules) which (1) had the highest shrunken r^2 value, and (2) accounted for 5% more variance than the second best model. If no one rule met this last criterion, then the most parsimonious rule (or rules) with respect to the number of free parameters was selected.

According to the first criteria, approximately 85% of the subjects' responses corresponded to one of the rules, 3% of the responses corresponded to two or more of the rules, and 12% of the subjects' responses did not correspond to any of the proposed rules. Within the second classification system, 54% of the subjects' responses were described by one rule, 35% by two or more rules, and 12% did not correspond to any of the rules. All rules except Rule C were used by subjects. Analyses of age differences in classification of rule use revealed: (1) younger children's prediction were less likely to conform to the rules than were older subjects' predictions; and (2) for the more stringent second set of criteria, older subjects' predictions were more likely to conform to a single rule.

Developmental changes in the use of rules were examined in two ways, both dictated by the fact that the number of individuals at any age who used a particular rule was too small

to be analyzed formally. The aim of the first analysis was to determine if subjects based their prediction solely on the number of items presented (Rules A and B) or considered both number of items presented and categorization of items (Rules D, E, F, and G). Shown in Table 3 is the number of subjects at each grade level who based their predictions solely on list length (Rules A and B) or considered both list length and categorization (Rules D through G). For both sets of classification criteria, age differences were found for type of rule usage, $X^2(4, N = 208) = 27.83$, $p < .01$; $X^2(4, N = 212) = 36.51$, $p < .01$. The number of individuals who based their prediction solely on list length decreased with age, while the number of individuals who considered both list length and categorization increased with age. Comparisons of adjacent grades yielded no significant differences using the first set of criteria and revealed one significant difference using the second set of criteria: most ninth graders used Rules A and B whereas most college students used Rules D and G (Yates corrected X^2 $(1, N = 91) = 5.72$).

The second analysis concerned understanding of immediate memory span. Also depicted in Table 3 is the number of subjects at each grade level whose predictions reflect

understanding of immediate memory span, that is, users of Rules B, F, and G, as well as those whose predictions do not, users of Rules A, D, and E. Age differences in understanding of memory span were significant using the first set of criteria, $X^2(4, N = 204) = 10.03$, and marginally so for the second set, $X^2(4, N = 129) = 9.14$. Comparisons of adjacent grades did not reveal any significant differences. Again, as indicated in Table 3, there is a developmental trend reflecting an increase in understanding of memory span. Specifically, although a substantial number of the younger subjects considered memory span, the percentage of subjects whose predictions reflected an understanding of memory span increased steadily with age.

Thus, the primary findings for rule usage converge with the findings of the analyses of variance. Specifically, these findings were: (1) developmental differences in consideration of both number of items presented and categorization of items for both sets of classification criteria; and (2) developmental differences in understanding of memory span.

Recall Performance

Perhaps young children were insensitive to the impact of number and categorization because in fact these variables had a negligible impact on recall. To assess this possibility, mean

number of words recalled (see Figure 1) was analyzed with a 2 (Category) X 6 (Number of items presented) X 5 (Age) analysis of variance. All main effects were significant, F's $\geq$ 38.51, as were the two-way interactions of Number with Age, $F(20,375) = 4.83$, and Number with Category, $F(5,375) = 16.00$. Analyses of the simple main effects of category and of number of items presented at each grade level revealed that recall (1) was greater for categorized than uncategorized lists at all grades and (2) increased with the number of items presented for all age groups. That is, at all age levels, recall was influenced by list length and categorization of items. Furthermore, because the three-way interaction of Age, Number, and Category was not significant, $F(20,375) = 2.39$, these variables had much the same effect on recall at all age levels. Therefore, developmental differences in predictions cannot be attributed to the differential impact that these variables have on recall at different age levels.

Difference Score

One-third of the subjects were asked to recall sets of items that differed on list length and categorization. To examine the relation between recall performance and subsequent predictions, difference scores were computed for each type of memory

problem presented (e.g. 4 categorized items, 8 uncategorized items). These difference scores were obtained by subtracting the number of items subjects predicted they could recall from the number of items they actually recalled. Next, the difference scores were analyzed with a 6 (Age) X 2 (Category) X 6 (Number) analysis of variance. The main effects of age, $F(4,75) = 14.49$, category, $F(1,75) = 34.74$, and number, $F(5,375) = 10.07$, were significant as were all two-way interactions involving the three variables, $F \geq 2.67$. The mean difference scores for each of the two-way interaction are presented in Figures 2 and 3.

Of particular interest are the developmental differences in children's ability to predict their recall performance. As can be seen in Figure 2, younger children grossly overestimate their performance; third and fifth graders overestimate their recall on uncategorized lists, but not categorized lists; adults actually underestimate recall on both lists. As indicated in Figure 3, this developmental shift from overestimation of recall to slight underestimation also occurs as list length increases. For short lists (4 or 6 items), all but first graders estimate their recall with reasonable accuracy; first graders overestimate their recall. As list length increases, the two youngest groups increasingly

overestimate their ability, the intermediate age groups slightly overestimate their actual recall, and adults actually slightly underestimate their recall ability.

CONCLUSIONS

The present study was designed to address two questions: (1) are there developmental differences in children's predictions of their own recall; and (2) what evaluative rules do children use to form their predictions. With respect to the first question, the principal findings were: (1) young children grossly overestimated their recall regardless of whether items were categorized; (2) third- and fifth-graders overestimated recall ability for uncategorized items, but not for categorized lists; (3) adolescents and adults recognized that categorization of items benefits recall only when list length exceeds immediate memory span; and (4) adults slightly underestimated their ability to recall on both categorized and uncategorized lists.

The second question concerned the evaluative rules subjects used to form their predictions. The pattern of young children's predictions was best described by rules that were based upon list length only. In contrast, adolescents' and adults' predictions were best described by rules that reflected understanding of list length and categorization, and the relation of these two variables to immediate memory span.

Table 1

Equations Defining Rules A Through G

Rule A	$Y = AX + B$
Rule B	$Y = A(1-e^{-BX})$
Rule C	$Y = A$ for categorized lists $Y = B$ for uncategorized lists
Rule D	$Y = AX + B + C$ for categorized lists $Y = AX + B$ for uncategorized lists
Rule E	$Y = AX + B$ for categorized lists $Y = CX + D$ for uncategorized lists
Rule F	$Y = A(1-e^{-BX})$ for categorized lists $Y = C(1-e^{-BX})$ for uncategorized lists
Rule G	$Y = A(1-e^{-BX})$ for categorized lists $Y = C(1-e^{-DX})$ for uncategorized lists

Note: X refers to the number of items presented; Y refers to predicted recall.

Table 2

Recall Predictions as a Function of Category and Number

	Number of Items Presented					
	4	6	8	10	12	20
Grade	Categorized Items					
First	3.82	5.40	6.31	7.38	8.31	10.71
Third	3.95	5.65	6.66	7.27	8.35	10.26
Fifth	4.00	5.74	6.78	7.38	8.46	9.86
Ninth	3.95	5.76	6.90	7.75	8.64	10.17
College	3.98	5.89	7.24	7.99	8.88	10.14
	Uncategorized Items					
First	3.73	5.06	5.81	7.07	7.71	10.46
Third	3.92	5.43	6.26	6.72	7.58	10.25
Fifth	3.97	5.58	6.47	7.02	7.35	9.23
Ninth	3.99	5.52	6.29	6.89	7.34	8.92
College	3.89	5.39	6.19	6.36	6.65	7.73

Table 3

Number of Subjects at Each Grade Level Whose Predictions Reflected Consideration of List Length Only (Rules A and B) or Both List Length and Categorization of Items (Rules D, E, F, and G) for Each Classification Criteria

	First Classification Criteria				
	Grade Level				
Type of Rule	First	Third	Fifth	Ninth	College
Rules A-B	22	25	23	14	9
Rules D-G	13	13	21	30	38
	Second Classification Criteria				
	Grade Level				
Type of Rule	First	Third	Fifth	Ninth	College
Rules A-B	31	32	32	25	14
Rules C-G	7	7	12	19	33

Table 3 continued

Number of Subjects at Each Grade Level Whose Predictions Reflected Understanding of Memory Span (Rules B, F, and G) or Failed to Consider Memory Span (Rules A, D, and E) for Each Classification Criteria

First Classification Criteria

	Grade Level				
Type of Rule	First	Third	Fifth	Ninth	College
Rules A, D, and E	10	10	8	6	3
Rules B, F, and G	24	25	36	37	44

Second Classification Criteria

	Grade Level				
Type of Rule	First	Third	Fifth	Ninth	College
Rules A, D, and E	1	5	2	3	0
Rules B, F, and G	11	17	28	27	35

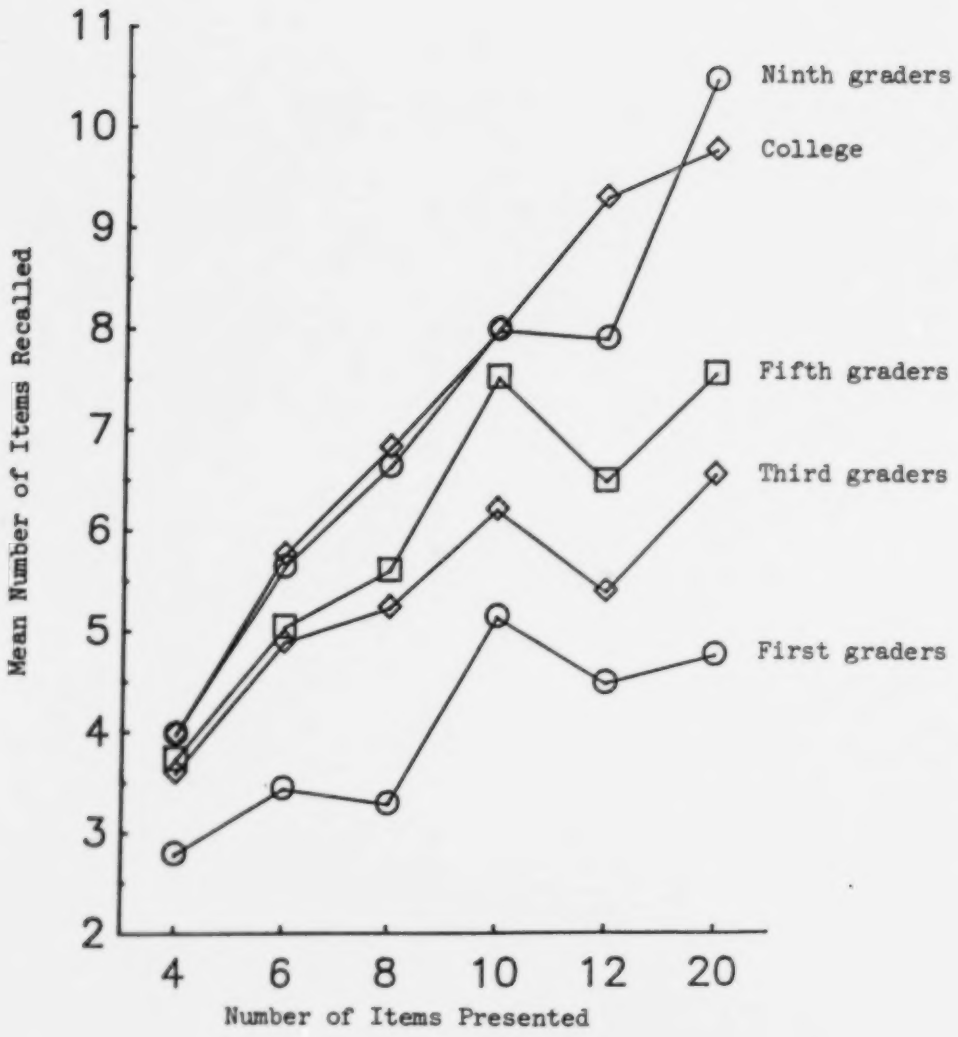

Figure 1

Mean Number of Items Recalled as a

Function of List Length and Age Level

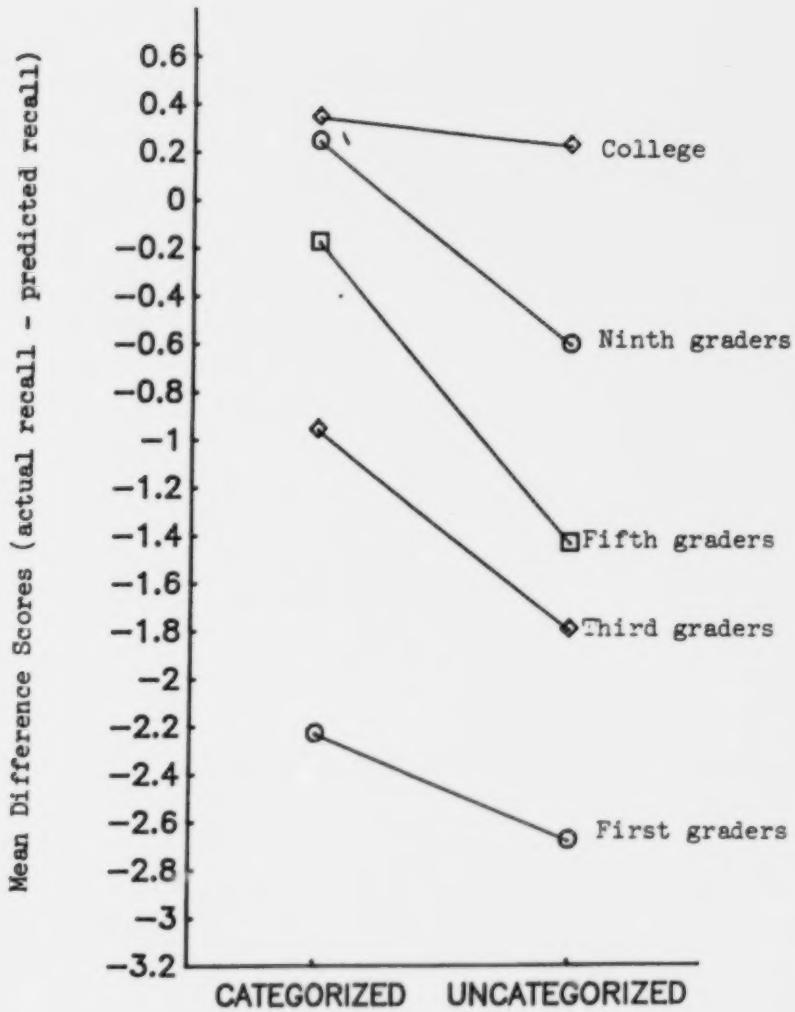

Figure 2

Mean Difference Scores Between Predicted Recall and Actual Recall as a Function of Categorization and Age Levels

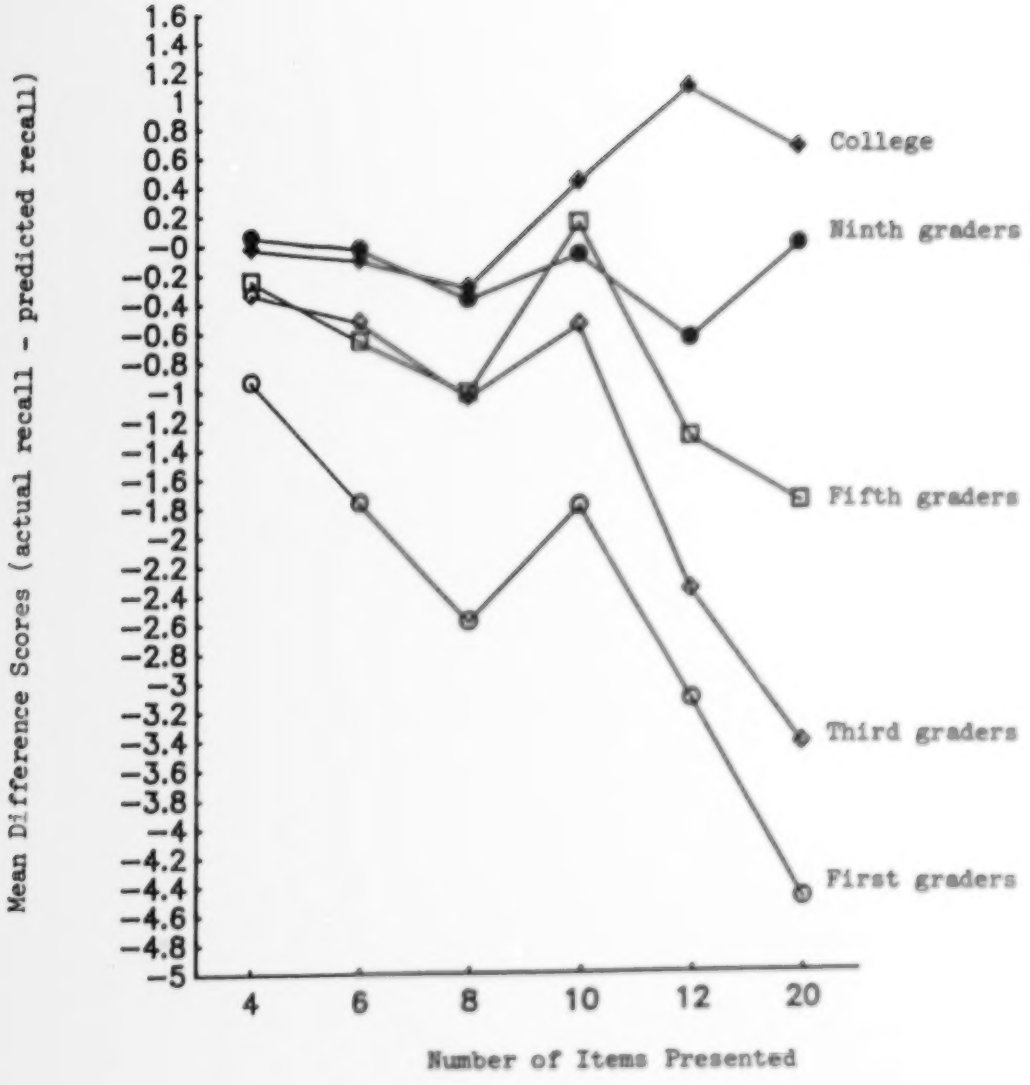

Figure 3

Mean Difference Scores Between Predicted Recall and Actual Recall as a Function of List Length and Age Level

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